DESIGN GUIDE FOR BA200 SERIES MODULES

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ABSTRACT: This document contains information regarding the design of BA200 Series Modules. This document includes designing for electromagnetic compatibility, modules with external I/O, modules without external I/O, cabling issues, labeling of BA200 Series Modules, documentation procedures from BA200 Series Options and Modules, and design examples. Also included are introductions to the BA200 Series Enclosures and Bulkheads.

APPLICABILITY: This document applies to all design engineering and manufacturing groups responsible for the design and manufacture of modules for the BA200 Series enclosures. It is mandatory for modules to comply with applicable Digital standards and tests.

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1 INTRODUCTION

The BA200 Series is a family of microsystem enclosures. Each of the enclosures has a six- or twelve-slot backplane and one or two modular power supplies (H7868). BA200 Series enclosures can be mounted vertically, in a rack, or on a wall. For example, the BA213 mounts vertically inside a cabinet such as Digital's H9644. BA200 Series Enclosures also exist as floor standing, movable, pedestal units with plastic skins. Figure 1 illustrates a BA213 Pedestal unit. Some of the different types of BA200 Series Enclosures include the BA213, a 12-slot enclosure with a storage device area; the BA214, a 6-slot enclosure with no storage device area; and the BA215, a 6-slot enclosure with a storage device area.

The BA200 Series card cage is designed so that all modules, cables, and options can be accessed from the front (Figure 1). The module bulkheads are designed for easy system access and maintenance, and provide containment of internally generated electromagnetic energy emissions. The bulkheads also provide protection against externally generated radio frequencies. Refer to subhead 1.2.

It should be noted that, although BA200 Series Bulkheads were originally designed for BA200 Series Enclosures (and will be referred to as BA200 Series Bulkheads for the remainder of this document), they may be compatible with BA200-like enclosures (spin-offs), which may follow. The use of these bulkheads is not solely limited to BA200 Series Enclosures.

Figure 1: The BA213 Pedestal

1.1 HOW THE BA200 SERIES ENCLOSURE CONTENDS WITH EMI

The BA200 Series Enclosure uses the concept of the Faraday Shield to form a six-sided grounded electrical shield. This shield acts as a barrier placed around the circuitry emitting electromagnetic energy. The BA200 Series Enclosure thus contends with EMI through the following functions:

1. Keeps frequencies generated by the system (power supply noise, antenna effect from modules, and so forth) at a minimum.
2. Keeps frequencies that do get generated inside the enclosure from leaking to the outside.
3. Prevents externally generated radio frequencies from entering the enclosure.

Figure 2: Faraday Shield

1.2 WHAT IS A BULKHEAD?

The BA200 Series Bulkheads are pieces of the enclosure that, when all are installed, actually form one side of this six-sided shield. The design of the BA200 Series bulkheads allows for the accommodation of I/O connectors, LEDs, and switches. Openings can be made in the bulkhead to accommodate these items but guidelines must be followed in order not to jeopardize the integrity of the Faraday (EMI) shield. Ultimately, the Shielding Effectiveness of the enclosure is directly proportional to the number and size of any discontinuities (slots, apertures) in the six-sided shield. The BA200 Series bulkheads also eliminate the need for internal cabling if the handle variety is used in conjunction with right angle I/O connectors soldered directly to the module. (Internal cables are a common source of EMI emissions.)

A bulkhead provides EMI emissions containment for a slot in a card cage. A bulkhead can be of the handle variety when it is attached (riveted) directly to a module or of the cover variety when it is not attached to a module and simply sits over a card cage slot. Bulkheads attached to modules are called handles, and can be either recessed or flush. Bulkheads not attached to modules are called covers, and can be either single or double width. Double-width covers cover two card cage slots. All handles are single width. All covers are flush.

This guide identifies the four kinds of bulkheads as follows:

- Recessed handle (70-23741)
- Flush handle (70-23742)
- Single cover (70-23981)
- Double cover (70-23982)

Figure 3 is a tree that illustrates the types of BA200 Series Bulkheads.

Figure 3: Types of BA200 Series Bulkheads

Each bulkhead has two captive quarter-turn phillips screws to hold it in the card cage. Each handle has release levers to help install or remove the module from the card cage. Each bulkhead also has a reserved area at its upper end for a module identification label, and a reserved area at its lower end for a module revision label. Figures 4 through 7 illustrate the types of bulkheads. Please note that the 74-38263, 74-38310, 74-38311 bulkheads are sheet metal parts and will eventually replace the 74-33638, 74-33635, and 74-33687 cast parts.

NOTE

The part numbers of the various bulkhead pieces (torsion springs, grounding clips, and so forth) are subject to change due to enhancements or value engineering efforts.

Figure 4: Recessed Handle (70-23741)

Figure 5: Flush Handle (70-23742)

Figure 6: Single Width (70-23981)

Figure 7: Double Width (70-23982)

1.3 BULKHEAD FEATURES

BA200 Series bulkheads are designed to provide:

- EMI emissions shielding
- Added rigidity to the module (for the attached handle type)
- Space for I/O connectors
- Space for switches and diagnostic LED windows
- A location for module identification and revision labeling. Switches, LEDs and connectors can also be identified by means of silk screening the bulkheads.
- A latching mechanism for module insertion and extraction (for the attached handle type)
- Low impedance bonding between I/O transceiver ground and chassis ground
- Space for interface/adaptive circuitry

1.4 WHEN TO USE A GAP FILLER

When installing a cover or flush handle to the left of a recessed handle, a gap filler (70-24071-01) must be attached to the flush bulkhead to maintain the continuity of the Faraday Shield and contain EMI. It is also necessary to attach a gap filler to a cover being installed to the right of a recessed handle. Without the gap filler, a slot will exist and allow electromagnetic energy to “leak” to the outside of the enclosure. The gap filler has four sets of finger stock that provide an effective connection between the bulkheads, thus maintaining the continuity of the shield. Attaching the gap filler is relatively easy. Flush handles and covers have screw holes at the top and bottom of each side for the installation of the gap filler. Figure 8 shows how a gap filler is attached to a bulkhead.

Figure 8: Gap Filler Installation

1.5 BEFORE INSTALLING A MODULE

To provide a low impedance path to the chassis and maintain continuity between bulkheads, handles and covers are equipped with transient protection EOS and EMI clips. These clips provide chassis ground through the module bulkhead. Before installing a module, perform the following procedure to help guarantee that the clips are in good condition:

1. Ensure that there is no residue or corrosion on the EOS and EMI clips located on the module bulkhead. If there is residue, remove it with isopropyl alcohol or other approved mild cleaners. Also, ensure that the EOS and EMI clips on the gap filler assembly are free of residue and corrosion.
2. Ensure that the EOS and EMI clips on the bulkhead are in an arch shape. When depressed slightly, they should return to their original shape.
3. If any clip is missing, broken, distorted or corroded, replace it with EOS clip P/N 12-26922-01 or EMI clip P/N 12-26340-01.

2 DESIGNING BA200 SERIES MODULES

This heading describes how to adapt or design a module for use with a BA200 Series bulkhead. It explains the ramifications of using a particular type of bulkhead and offers suggestions on which type of bulkhead may be the best solution for a particular scheme.

This heading also explains the proper layout for modules being designed for use with BA200 Series bulkheads and offers information regarding various electromagnetic compatibility issues (for example, design strategies that will aid in the reduction of EMI emissions).

Design considerations differ for modules with and without external I/O connectors. For example, it is easy to accommodate a module without external I/O connectors. A module with external I/O connections requires more planning, since it involves choosing the right I/O connector that will mount on the bulkhead, a method of connecting the I/O connector to the module (for example, internal cable, right angle connector), and what type of external cable will be connecting to the I/O connector.

When designing an entirely new module, reducing EMI emissions with the proper printed-circuit board layout techniques requires even more planning.

2.1 MODULES WITHOUT EXTERNAL I/O

A module without external I/O is defined as a module which does not connect to anything outside of the enclosure. Some examples are the TQK50, TQK70, RQDX3 and MS650. The TQK and RQD controllers connect to their respective storage devices via flexible round cables which are routed internally to the enclosure. The MS650 memory module is seated in the slot(s) next to the CPU and uses a flat internal cable to connect to the CPU module. All of these modules use the cover type of bulkhead (70-23981-01). The covers used require no mechanical alteration for connectors since all connections made to other system components are done within the enclosure. Although a handle can be used for modules without external I/O, the easiest approach would be to use a BA200 Series cover. This is left to the designer. A quad-height module can be inserted into the backplane and simply covered with the BA200 Series cover. When using a cover or handle with a dual height module, a 74-33507-01 dual blank must be used to support the module.

If a module has an LED or switch, then the bulkhead that is used must be designed to accomodate the switch or have a hole for viewing the LED.

Figures 9 and 10 illustrate the possible single cover (70-23981) and quad height module combinations.

Figures 11 and 12 illustrate the possible single cover (70-23981) and dual height module combinations.

Figure 13 illustrates a double cover (70-23982) being used to cover two slots of modules with no external I/O.

Figure 9: Single Cover and Quad-Height Module with the 12-13113-01 Card Ejector

Figure 10: Single Cover and Quad-Height Module with the 12-13113-03 Card Ejector

A dual blank filler panel (74-33507-01) must be used for supporting dual-height modules. Figures 11 and 12 show how dual blank filler panels are used with dual-height modules.

Figure 11: Single Cover Dual-height Modules with 90-08337 Plastic Module Handle

Figure 12: Single Cover Dual-Height Module with 12-13543 Plastic Module Handle

Figure 13: Double Cover Implementation

2.2 MODULES WITH EXTERNAL I/O, LEDs, OR SWITCHES

Modules with external I/O are described as modules which will be connected to an I/O device which is external to the enclosure. These devices include disk drives, tape drives, terminals, printers, modems, and so forth, which connect to the module at a connector on the module's bulkhead. This requires that the bulkhead be designed to accommodate such a connector. Some of the different types of connectors available for use include d-subminiature connectors (for example, 9-pin, 15-pin, 25-pin, 37-pin and 50-pin), integral-latch connectors such as those used on the CXA16 and CXB16 modules, Miniature Modular Jacks (MMJs), and BNC connectors. A module with external I/O involves some of the same considerations as a module without external I/O. However, there are additional issues that must be considered for modules with external I/O. This subhead deals specifically with these concerns.

2.2.1 Covers Versus Handles

If a cover is used, the clearances between a module and a cover for circuitry and/or connectors are shown in Figures 9 through 13. Figures 9 through 13 illustrate BA200 Series covers used with modules that have the traditional metal card ejectors and plastic magenta handles attached. The amount of available area behind the cover, to be used for connectors and/or circuitry, is dependent upon which type of traditional module handle is used. The traditional module handles include the 12-13113 metal card ejectors and the 12-13543 and 90-08337 plastic magenta module handles.

Although handles or covers can be used for a module with external I/O, handle designs are preferred. Handle designs allow the use of right angle connectors which can be soldered directly onto the module's printed-circuit board. This eliminates the need for internal cables which would traditionally be used to connect the printed-circuit board header (connector) to the I/O connector on the bulkhead. The absence of these internal cables removes the possibilty of these cables radiating unwanted electromagnetic energy and the possibility of being scratched by component leads of adjacent modules. In both cases, successful Digital standard testing is jeopardized. See Figures 14 and 15 for drawings of modules with handles.

Figure 14: Recessed Handle

Figure 15: Flush Handle

2.2.2 Cabling Clearances

When using a handle, determine whether to use a flush handle (70-23742) or a recessed handle (70-23741). The use of one or the other depends on the kind of I/O connectors used. Connectors on BA200 Series Bulkheads must adhere to certain clearances. Depending on whether a bulkhead is flush or recessed, its connectors and switches must fall within the specified clearances between the face of the bulkhead and the back surface of the enclosure's front panel. The connector at the end of the external cable must not exceed 4.00 cm (1.57 in) depth for flush handle or 6.5 cm (2.6 in) depth for a recessed handle. See Figure 16. If the module requires a rather large external cable and connector, a recessed handle would be necessary to meet the clearance requirement between the inside surface of the enclosure's front panel and the front surface of the bulkhead. The recessed handle, on the other hand, reduces the space between the module and the handle. This may be a restriction if an internal cable is used to connect the printed-circuit board header (connector) to the I/O connector on the bulkhead.

Some of the existing shielded low-profile external I/O cables, designed for use with a flush bulkhead, include the 17-02169-01 (37 position), 17-02172-01 (9 position), and the 17-02173-01 (50 position).

Figure 16: External Cable Clearances for BA200 Series Bulkheads

Using internal cables to connect the printed-circuit header on the module to I/O connectors on the bulkhead is one way of making the module etch usable in enclosures other than the BA200 Series. See Figures 17 and 18.

When long internal cables are needed, use round flexible type cables instead of ribbon cables. Round flexible cables do not interfere with air flow inside the enclosure. Round flexible cables are also more rugged and withstand more scratching from the component leads of adjacent modules. Scratching may occur when adjacent modules are removed or installed.

Figure 17: Recessed Handle Design Using an Internal I/O Cable

Figure 18: Flush Handle With Internal I/O Cable

2.2.3 Available Machining Area

The machining of various bulkheads must be contained within the specified legal limits to ensure that functionality and manufacturability are not jeopardized. Figure 19 illustrates the area of the various bulkheads usable for the mounting of connectors, switches, light emitting diodes (LEDs), and so forth.

Figure 19: Usable Area of The Various Bulkheads

2.2.4 Riveting Holes

When using a handle type bulkhead, the bulkhead is riveted directly to the printed-circuit board. This gives added rigidity to the module and allows for insertion and extraction of the module via the handle's latching mechanism (levers). The rivet holes must be 0.142 +0.000/-0.005 inches in diameter. Dimensions for placement of the holes in the printed-circuit board are shown in Figure 20. For more information regarding printed-circuit board dimensions, please refer to EL-SM030-00, *DEC STD 030 Module Manufacturing Standard*, *DEC STD 176 Printed-Wiring Board Acceptance Criteria*, and EL-ENPCB-00 *PC Board Engineering Handbook*.

Figure 20: Rivet Hole Placement

2.2.5 Placement of Right Angle I/O Connectors

As mentioned earlier, the preferred design for a module with external I/O is one which uses right angle I/O connectors. Figures 21 through 25 show where to place holes on printed-circuit boards for two 9-pin, 25-pin, 37-pin and 50-pin right angle connectors, respectively. Use the same dimensions and one of the locations if only one connector is needed. These dimensions can also be referenced if combinations of the different connectors are needed. It is not mandatory that these dimensions be used. The following figures are presented as examples.

Figure 21: Dimensions and Locations of Holes For 9-Pin Connectors

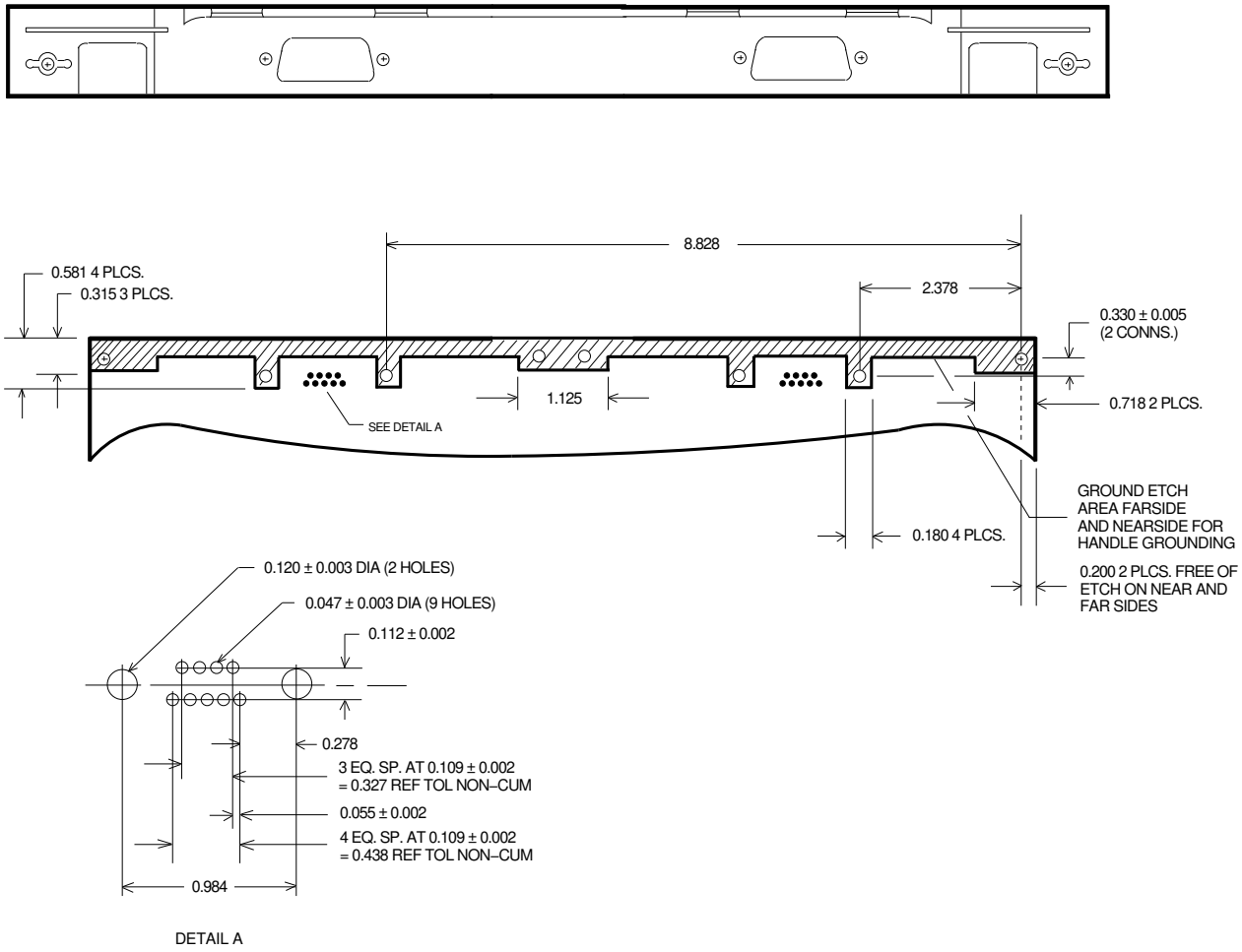

Figure 22: Dimensions and Locations of Holes For 15-Pin Connectors

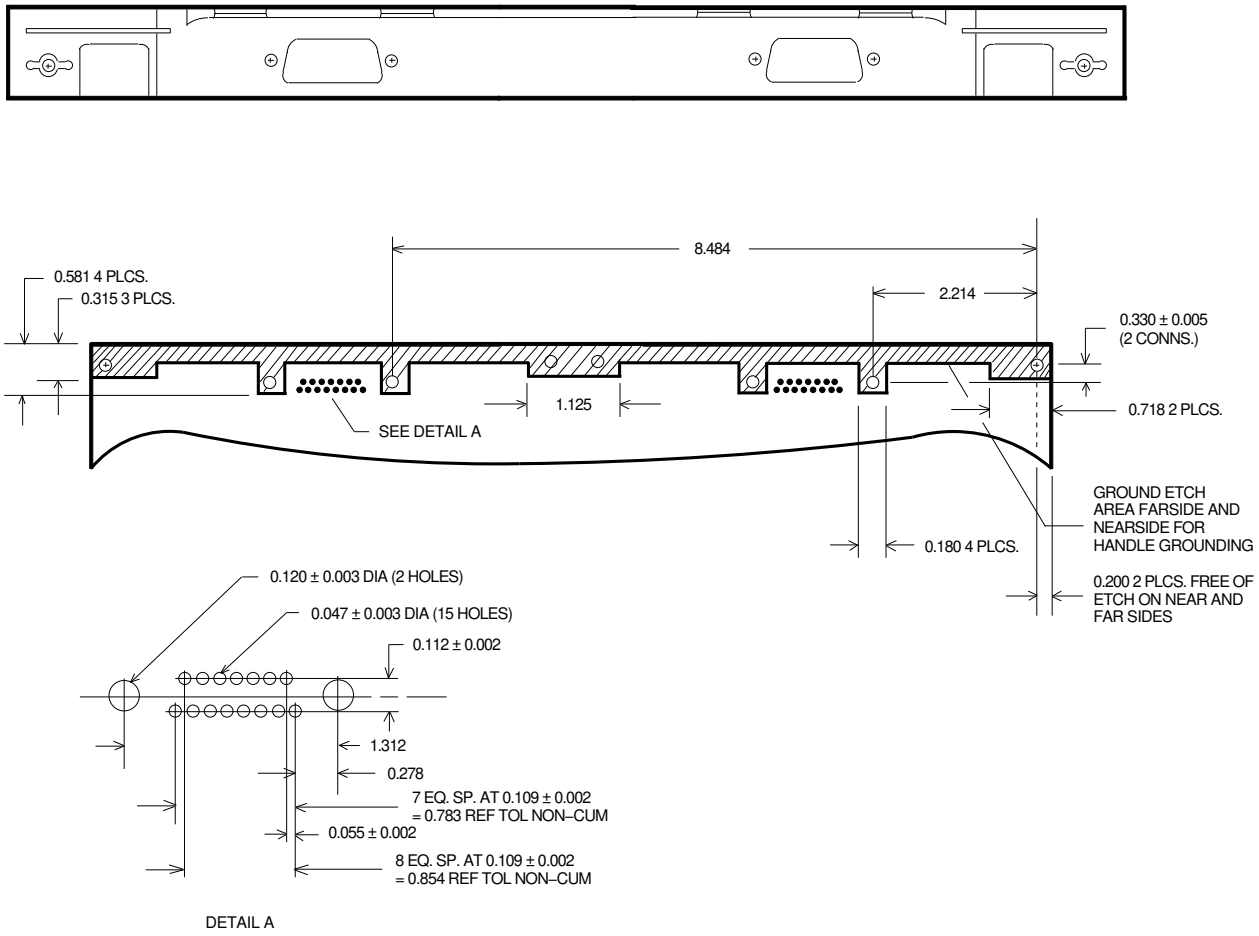

Figure 23: Dimensions and Locations of Holes For 25-Pin Connectors

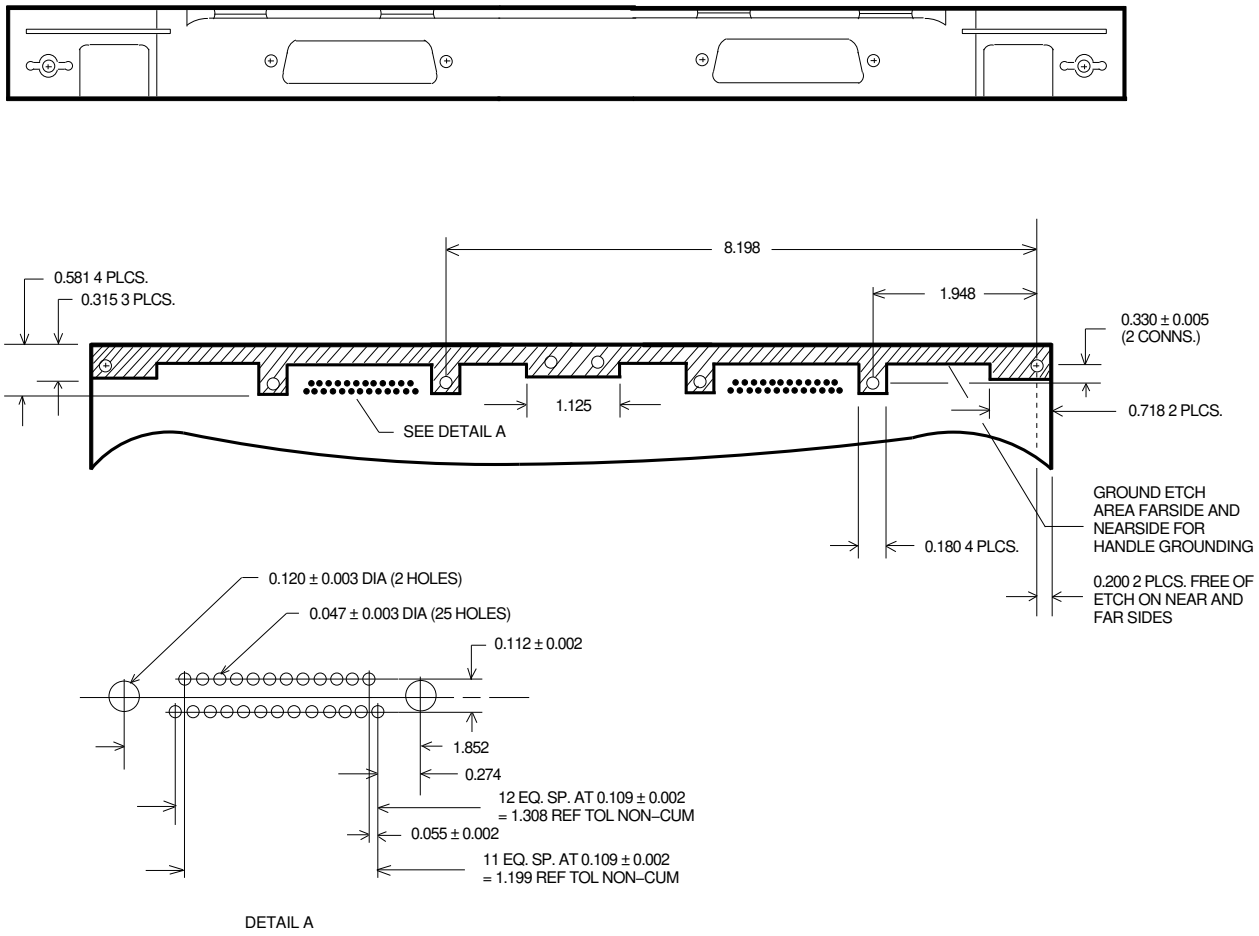

Figure 24: Dimensions and Locations of Holes For 37-Pin Connectors

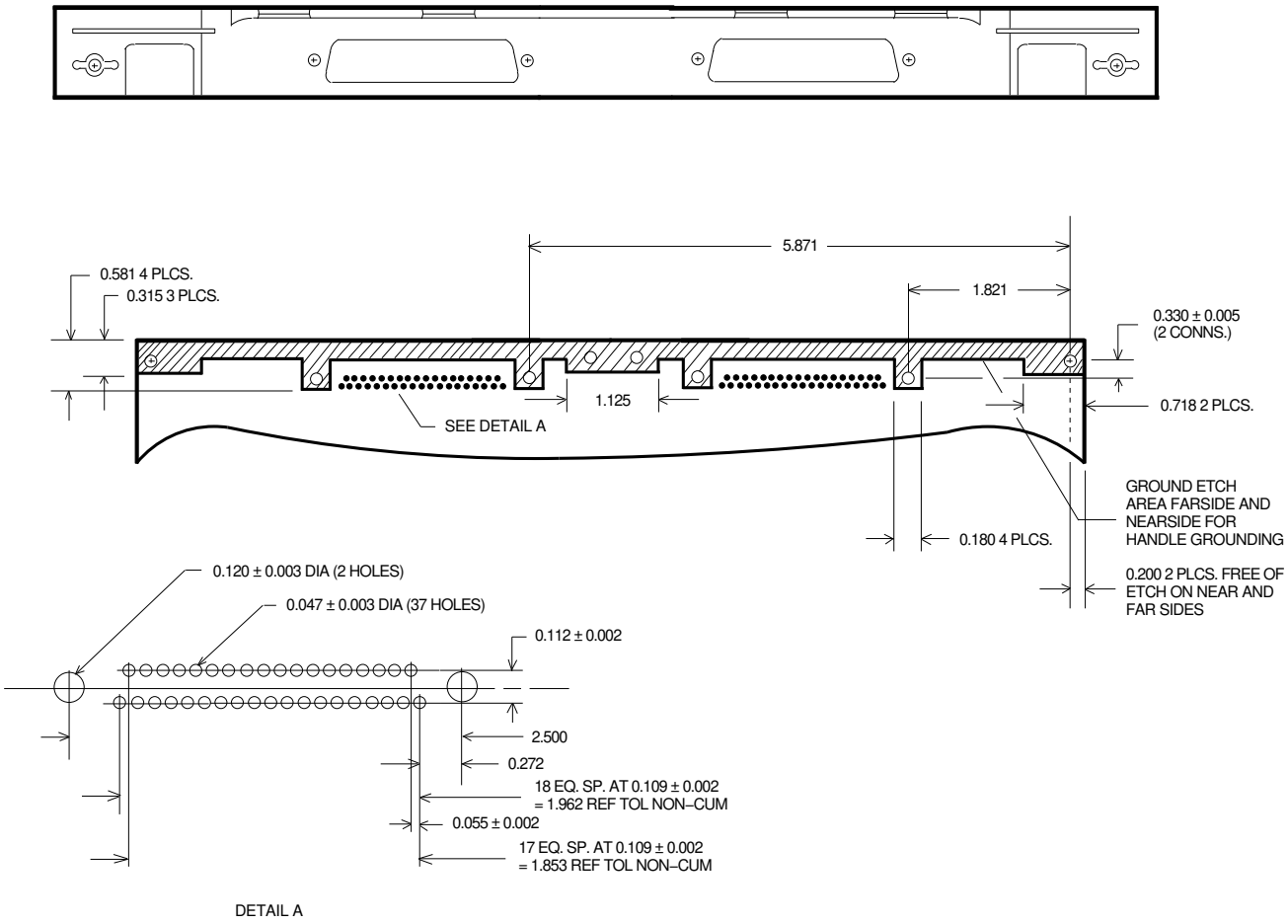

Figure 25: Dimensions and Locations of Holes For 50-Pin Integral-Latch Type Connectors

2.3 COMPONENT CLEARANCES

Rule 5150 of *DEC STD 030-5 Module Manufacturing Standard - Module Assembly and Component Insertion Rules* states that component bodies must clear any protrusions of an adjacent module plugged into the backplane. The maximum component height, referenced from side one of the module's printed-circuit board, is dependent on certain worst-case variables, such as finished board thickness, the distance between slots in the card cage, and the protrusion of component leads from side 2 of the adjacent module. The finished board thickness depends on the worst-case dimension of the particular board in question (0.058, 0.062, 0.093, 0.125, and so forth), the type of soldermask being used (ink film = 0.002 inches, dry film = 0.003 inches) and the number of sides of the board that are being soldermasked. DEC STD 030-5 states the maximum preferred component lead protrusion is 0.062 inches. The distance between modules in the BA200 card cage is 0.095 +/- 0.005 inches. An example of maximum component height for a printed-circuit board of 0.058 +0.007/0.006 inches (with dry film soldermask on both sides) for a BA200 Series enclosure is given in Figure 26.

Figure 26: Example of Maximum Allowable Component Height

2.4 BA200 SERIES MODULE/OPTION LABELING

DEC STD 178-2 Digital Marking Requirements for Subassemblies: Field Replaceable Units (FRU) and Non-Field Replaceable Units states: "FRU sub-assembly marking identification must be placed in a location that is visible without having to lift, tilt or disturb the part to see the marking".

Digital Field Service has the need to ascertain the revision level of the major Field Replaceable Units (FRUs) without moving them or powering off the system. In the past manufacturing has marked their stage 1 material with the assembly revision on the side of the FRU and field service had to power down the system and remove the FRU in a running system in order to identify the FRU revision.

For module identification purposes, the BA200 Series Option design engineer must create a variation of the 36-26883 Module Identification Label with an ECO to the 36-26883 Purchase Specification. This label is attached to the upper indented area of the BA200 Series bulkhead.

Figure 27: 36-26883 Module Identification Label

For module revision identification, the option design engineer must choose the appropriate existing variation of the 36-29163 BA200 Module Revision Label (rolled). The 36-29164 is the sheeted version.

Figure 28: 36-29163/36-29164 Module Revision Label

Table 1: Module Revision Label Variations

	ROLL	SHEETED
A's	= 36-29163-01	36-29164-01
B's	= -02	-02
C's	= -03	-03
D's	= -04	-04
E's	= -05	-05
F's	= -06	-06
REV	= -07	-07
Blank	= -08	-08
Pad	= -09	-09
H's	= -10	-10
J's	= -11	-11

The -08 variations are BLANK labels so FS can use it for vendor information or labeling blank handles as such.

The -09 variations are "PADs" or packages of one of each sheet designed to fit in your pocket so FS can take it anywhere and use it to label any system.

2.4.1 Location of Module ID and Revision Labels on BA200 Series Bulkheads

Figure 29: Single-Width Bulkheads

Figure 30: Double-Width Bulkheads

2.4.2 Recommended Implementation of BA200 Series Option Labeling

All module identification and revision labels are in roll form per manufacturing's request.

Stage 1 manufacturing sites order pre-printed labels on rolls.

Stage 2 manufacturing sites order a blank revision label so they can stamp the appropriate revision on any module that does not have an integral handle (for example, TQK50). Using this procedure eliminates ECOs of the system KPL and simplifies the labeling procedure.

Stage 1 manufacturing adds the appropriate revision label to a product at the same time as they bar code label it, or whenever best fits their particular manufacturing process.

Stage 2 manufacturing is more complex because some FRUs do not have attached handles (for example, TQK70). In another case the H3600 CPU handle covers a KA CPU and one MS memory, so it must be handled differently.

Simple Guidelines:

a. FRUs (modules) that have unattached handles must have the ID and revision label applied during the system assembly. It is suggested that this is the best time to apply the labels. This process should work for all cases of FRUs that have unattached bulkheads. ID and Revision Labels must correspond to the module that lies behind the cover.

b. The H3600, H3601, H3602, and H3603 are dual wide "covers" and are examples of bulkheads that are FRUs unto themselves. They cover a CPU module and a memory module. For these cases, the ID and revision labels must also correspond to the module that lies behind it.

c. Revision Labels for options using attached bulkheads (recessed or flush handles) shall correspond to the revision of the M1234-P* assembly.

All Field Service labels will be in sheet form and packaged as a small pad that can be easily carried in the pocket or in the tool kit. When an FRU has an FCO installed in the field the engineer can update the revision label from the field service kit. If any FRU did not have a revision label from manufacturing, as in early ships of the MV3600s, the engineer can add the label easily. The labels can also be used to mark the revision of the mass storage devices and any other major FRU with a hidden revision label.

Field service will receive a "pad" of labels cut from sheets with the availability to order separate sheets when they exhaust any one label.

If the FRU revision is of a higher designation than the pre-printed labels, then the -07 blank variation can be used and the current revision can then be stamped or written.

2.5 BULKHEAD EVALUATION KIT

The Bulkhead Evaluation Kit is for individuals who do not know which kind of bulkhead to use with a module. This kit contains one each of the other kits available from Digital, as Table 1 shows. This kit is intended to help engineers determine the bulkhead best suited for their application. The bulkhead evaluation kits can be used to build only prototypes and not revenuable units.

Table 2: Bulkhead Evaluation Kit - H3650

Part	Description	Quantity
1	H3651 - Bulkhead Assembly Kit	1
2	H3652 - Recessed Handle (70-23741-01)	1
3	H3653 - Flush Handle (70-23742-01)	1
4	H3654 - Double Cover (70-23982-01)	1
5	H3655 - Single Cover (70-23981-01)	1
6	H3656 [1]- Dual Filler Panel	1
7	H3657 [1]- Gap Filler Kit	1
8	BA200 Series Module Design Guide (EK-BA200-DG)	1

[1] These kits are not included separately in the H3650, but are included in the H3651.

Figure 31 shows the different components of the Bulkhead Evaluation Kit.

Figure 31: Contents of Bulkhead Evaluation Kit (H3650)

2.5.1 Modifying the BA200 Series Bulkheads

In the process of building prototypes, it may be necessary to modify a bulkhead to accommodate I/O connectors, LEDs, cables, and so forth. The first choice for modifying a bulkhead that has been plated is laser cutting, followed by conventional machining (milling, drilling). Punching is not recommended after plating. Cutting fluid may be required, but may cause loss of adhesion of silkscreen. Because a bulkhead my be scratched or nicked during modifying, protect the surfaces during modification with a masking tape, such as 3M 209 or 213 tapes supplied by 3M Industrial Tape Division. Apply the tape just prior to modification. Marks for dimensions of any holes can be made on the tape. Remove the tape after modification.

CAUTION

Machining operations in the areas of the EMI and/or EOS clips which cause the alteration or elimination of these clips will result in the loss of FCC compliance of the device and/or system.

Cleaning the Bulkheads

After modifying or cutting out a bulkhead, remove any cutting oils that may have been used for the rework. Use a solvent, such as alcohol, that will not destroy the plating. Do not wipe the surface of the plating with any abrasive material.

Retouching the Bulkheads

A bulkhead may need touch-up before it can be used. Some damage to plated surfaces can result from poor handling practices. This damage is most often cosmetic, in the form of scratches. Because of its finish, it is unlikely that the surface can be repaired to its original form. After a bulkhead is modified, the side walls of the holes or cutouts are unplated. The unplated sidewalls do not present a functional problem because the cutout will be loaded with a connector or switch. The side walls should not be used to make a shield contact.

No touch-up is required on cast bulkheads. However, unplated surfaces on sheet metal bulkheads must be protected from corrosion with touch-up paint. Using a cotton swab, apply the paint to the inside walls of the cutouts. If the paint is nonconductive, be careful not to paint the surfaces around the cutout. Paint on the surfaces around the cutout would interfere with contact with the installed connector.

2.6 DESIGN ALTERNATIVES

In designing options and modules for a BA200 or similar enclosure, the need may arise to use a nonconventional approach. Figure 32 illustrates a triple-width bulkhead cover. The triple-width bulkhead shown is nonconventional, but may be the solution to a particular design problem. It is shown here only as an example and it is left solely to the designer for further investigation.

NOTE

Non-conventional bulkheads are not supported by the Micro Systems Engineering Support Unit.

Figure 32: Non-conventional Bulkhead

3 DESIGNING FOR ELECTROMAGNETIC COMPATIBILITY

Correct printed-circuit board layout, proper grounding scheme (depending on type of I/O), choice of parts used in the design, clock speeds, and filtering techniques are all determining factors in a successful design. In order to ensure that all these issues are addressed, the BA200 Series module designer should consult with a qualified Electromagnetic Compatibility (EMC) engineer familiar with the BA200 Series of enclosures. This section serves as an introduction to the various electromagnetic compatibility design issues and heightens the designer's awareness of these issues. The designer can use the information provided to properly communicate his or her concerns to an EMC engineer. This section is not to serve as a substitute for consultation from an EMC engineer.

The EMC engineer is also a resource for proper design techniques with respect to electrostatic discharge (ESD) and electrical overstress (EOS).

3.1 EMI

One of the goals of a BA200 Series module design is to achieve a design that will generate a minimal amount of EMI. Less EMI generated by a module means the amount of EMI necessary to contain within the enclosure is less. Most of the EMI problems found in digital devices are the result of common-mode voltages/currents generated at the printed-circuit board/subassembly level and conducted or radiated to the outside world via wires, cables, or slots. Designing a module with the goal of minimizing EMI from product conception through the entire development process, will increase the likelihood of successful testing per *DEC STD 103-0 Electromagnetic Compatibility (EMC) Hardware Design Requirements*.

Table 3 lists and describes the kinds of noise that an effective design will reduce or eliminate.

Table 3: Sources of Noise

Noise Source	Description
Power supply noise	This appears in the supply voltage/ground and may get propagated to the I/O lines via the driver or receiver. The solution is to decouple the driver/receiver power input to the low impedance path to the ground plane.
Signal rise time	This can be a noise source if the signals are fast enough. The solution is to control the slew rate of an integrated circuit to an acceptable value.
Antenna effect	This is the noise picked up by the etch runs from the driver and receiver to the I/O connector. The solution is to keep these etch runs short.
Common mode noise	This is a voltage or current referenced to ground or the chassis. It is usually caused by magnetic or electric field coupling of energy from higher energy level circuits to lower energy level circuits, and can cause high-frequency noise to appear in the communication driver and receiver lines. The solution is to decouple the high-frequency noise via capacitors, thereby shunting the high-frequency energy to a low impedance plane tied by to the chassis via a low impedance path.

3.2 CONTROL OF EMI AT THE PRINTED-CIRCUIT BOARD

Control of EMI at the printed-circuit board level is important because most EMI originates on the printed-circuit boards. When a conductor is excited by a voltage or current, an electric or magnetic field is built up around it. When the driving force stops, that field collapses and its energy is returned to the conductor. It takes time for the field to collapse and return this energy. If the source has reversed itself before all of the energy is returned to the conductor, the remaining field energy will be repelled away into space. The conductor is now acting as an antenna. The amount of energy driven into space is dependent upon the excitation frequency.

3.3 COMMON IMPEDANCE COUPLING

Common impedance coupling (the transference of energy from one circuit or system to another through a common impedance path, resulting in EMI), can be prevented by separating I/O circuitry current returns from the current returns of the logic circuitry. BA200 Series bulkheads provide a separate return path for I/O and filter currents back to the power supply through the enclosure metal, thus eliminating a common impedance path and bypassing the noisy logic power distribution system. This scheme prevents electrical noise present in the logic circuitry from being induced (coupled) into the I/O circuitry which would allow it to radiate from the I/O cables.

Figure 33: Etch Grounding of a BA200 Module

3.4 MULTILAYER BOARDS AND LAYOUT GUIDELINES

The use of multilayer boards with multiple power and return layers is essential for maintaining low impedance of signal lines, maximum decoupling of power layers, lowest impedance across planes to minimize common impedance coupling, and, in some applications, a shielding effect if power and return layers are located on the outer layers. One reason why ground planes in printed-circuit boards are so effective in reducing radio frequency emissions is that if a current-carrying conductor is routed over a ground plane which is the return path, the return current is channelled immediately below the current-carrying conductor. This effectively forms a pair of balanced conductors whose fields tend to cancel each other. Ground planes can cause problems if uncontrolled groundplane currents from unrelated circuits can couple into one another via the common ground and power plane impedances. This is especially true of a dual power-ground plane arrangement.

Careful printed-circuit board layout should separate sources of high levels of radio frequency energy (clock oscillators, clock distribution lines, high-speed memory, video generator circuits, and so forth) from receptors (communications ports, printer ports, etc.), reduce common current paths, and minimize circuit loop areas. For some examples of designs, see the CXA16, CXB16 and CXY08 communications options.

Some guidelines for laying out BA200 Series modules are:

- At the very start of the design, separate high-speed circuits from those which are inherently slower. High-speed circuits will require very close attention.
- Design clock distribution and other high-speed, high-energy networks to be as short and straight as possible. Avoid crossovers with anything else. Keep etch runs of concern clustered together. Assure tightly coupled ground return paths that do not share space with other circuits.
- Clock lines should be adjacent to the ground plane layer, and not be allowed to jump haphazardly from one layer to another.
- Isolate and lay out very high speed circuits as though they were separate modules on the printed-circuit board. Techniques such as separate ground planes, controlled impedance traces, soldered-on metalwork, and special components may be necessary.
- Place I/O circuits at the edge of the board, close to the I/O connectors.
- Place sources inboard, away from any circuits which may leave the board.
- If the chassis is to be used as the I/O return, leave a high impedance path between the logic and I/O grounds. Leave a low impedance path between the I/O ground and the handle bonding etch. Figure 33 shows how the layout of the module should be structured. Note where paths of high and low impedance are located. Figure 34 illustrates a cross section of a design where the module and bulkhead (handle) are attached.
- Do not use a soldermask for the ground etch along the handle bonding area on Side 2 of the printed-circuit board. When a mask is not used, increased contact area with the handle is provided to ensure the lowest impedance path between I/O circuitry and chassis ground (I/O current return).

- Do not use a solder mask on Side 1 of the printed-circuit board where the connectors are mounted. When a mask is not used, increased contact area is provided to form the lowest impedance path to chassis ground.
- Use any unused area between the module and the bulkhead handle, where they make contact, as ground etch. Make multiple feedthrough holes between Side 1, Side 2, and the inner layer chassis ground plane.
- Place decoupling capacitors for the drivers, receivers, and protection devices between the strip of etch, used for bonding the module to the handle, and the power pins.
- Try to keep the etch, running from I/O connectors and protection devices to the transceiver devices, from extending more than 1.5 inches.
- Do not run etch from the I/O area to the logic area except for connection to the transceiver circuits.
- Do not run high-frequency lines across the I/O (chassis) ground plane.
- If a module is being debugged with an extender module, provide a means for connecting the I/O ground to the logic ground.

Figure 34: Cross Section of Handle

3.5 LOOP AREA

The magnetic emission and susceptibility of a circuit is a linear function of its loop area. Loop area is the area of plane described by a signal path, including its ground return. To minimize loop area, signals and returns should be run close to each other as pairs. Signal and return runs should be kept as short as possible and equal in length. A pair of conductors in close proximity, which carry equal and opposite currents and voltages, are balanced and will tend to cancel each other's electric and magnetic fields.

3.6 BYPASS CAPACITORS

Bypass capacitors will help keep current loops localized, but must be used below resonance. Use good quality, high-frequency capacitors, that is, with as low equivalent series resistance (ESR) values as practical. Individual decoupling capacitors may not have suitable performance at all frequencies. This situation would require the use of a parallel capacitor combination, one for high frequencies and another for low.

3.7 FILTERS

BA200 Series modules that are designed incorporating proper electromagnetic compatibility techniques may not require filtering. When filters are required, their function is to mismatch the energy transfer from the source to the load. In this case, the load is the I/O cable acting as an antenna. Trade-offs are often necessary between performance, ease of use, cost, and size of the filter.

Ferrite beads will reduce radio frequency currents in a circuit by raising the circuit impedance to those currents.

Some different types of filters are:

- Reactive (Capacitor and/or Inductor) - Reflect energy back to the source under ideal conditions.
- Capacitive - Shunt energy to the chassis to which it is bonded, depending upon the return impedance.
- Lossy Ferrite - Special case of Inductive filter which absorbs energy rather than reflects it, especially at higher frequencies.

A filtered connector (generally of the capacitive filter type) is sometimes useful in efforts to protect I/O circuitry against damage caused by electrostatic discharge (ESD).

3.8 PROTECTION DEVICES

Protection devices should be used for DEC 423, RS-423, RS-422, and RS-232C applications to protect the electronic circuits against damage due to severe ESD and EOS conditions. During severe conditions, the protection device should breakdown before damage occurs. The EMC Engineer will advise on the proper proximity of the protection devices to the I/O connectors and correct board layout that will ensure the devices operate properly and which protection devices to use if a particular device is not adaquate. Figure 35 contains some part numbers of some of the more widely used protection devices. See *DEC STD 052-4 Local Direct Connection (No Modem) for Serial Asynchronous Terminals and System Interfaces* for more information.

Figure 35: Protection Devices

3.9 I/O CONNECTORS

It is important to match the type of I/O with a suitable connector. When filtering is required, several options (such as the d-subminiature or champ connectors) are commonly used. It must be remembered that space on the printed-circuit board will be required for discrete filters when unfiltered connectors, such as the miniature modular jack (MMJ), are used.

A right angle I/O connector, which is directly mounted (soldered) to the printed-circuit board, eliminates the need for internal cabling (see Figure 36). Internal cables are a common source of EMI emissions.

It is important to note that a connector which will mate with a 360 degree shielded I/O cable must provide a 360 degree electrical connection to the cable's shield in order to maintain the continuity of the shield.

Figure 36: Right Angle Connector on Module

3.10 I/O (EXTERNAL) CABLES

Shielded cables must provide a 360 degree shield. A single outer shield is preferable. Multiple shields are primarily used to maintain signal integity. The use of pigtail grounding straps is not preferred and is limited to very slow speed I/O applications. In most cases within Digital, the only application of pigtail grounding straps is the German Regulation that data cables in excess of two meters in length be shielded. Therefore, DEC423 data cables used in Germany use pigtail grounding straps.

4 DESIGN EXAMPLES

The examples in this heading explain how to proceed in the design of modules for BA200 enclosures. Each example provides a product description followed by a suggested approach for solving the module design problems.

4.1 DOUBLE-COVER DESIGN EXAMPLE

This example shows how to use the space behind the double cover to attach circuitry and save space on the module. Refer to Figure 13 for clearances between modules and the double cover.

4.1.1 Product Description

The product consists of two quad-height modules connected by a private bus, in this case a ribbon cable from one module to the other. The product communicates to the external world by a serial line. The product also requires a baud rate switch and a two-digit seven-segment display that the user or field service can access.

Figure 37: Double Cover and Modules

4.1.2 Approach

One approach is to attach the segment display, switch, and serial line connector to a small PCB that gets mounted directly on the bulkhead. Such an approach offers the advantage of placing the drivers close to the display and the transceivers close to the connector, thus reducing noise problems and freeing additional space on the module.

The ideal bulkhead for this approach is a double cover (70-23982). The double cover provides space to mount the PCB and eliminates the need for two covers.

A good way to connect the bulkhead circuitry to the modules is to use a small (for example, 4-inch) ribbon cable that is soldered on the bulkhead PCB and is connected to the module by a Berg connector. See Figure 38. When the connector type on the module has been set, the modules are ready for layout. Refer to heading 2 for information on module layout.

Mount the PCB onto the double cover by using standoffs. Screw the PCB onto the cover.

Figure 38: Double Cover and Printed-Circuit Board

4.2 RECESSED HANDLE DESIGN EXAMPLE

This example shows how to proceed in the design of a module that requires nonstandard I/O connectors, switches, and LEDs, using a recessed handle.

4.2.1 Product Description

The product consists of one quad-height combination communication module with a serial line right-angle D-sub connector, two MMJ connectors, one selection switch and two LEDs. The module is shown in Figure 39.

Note that a right-angle D-sub connector was used in the module design. This type of connector is designed to extend through the hole in the handle.

Figure 39: Quad-Height Communication Module

4.2.2 Approach

This design uses a recessed handle because holes can be designed into this handle to fit the MMJ and right angle D-sub connector. The recessed handle designed to accommodate the MMJ connectors and the right angle D-sub connector is shown in Figure 40.

Figure 40: Handle and Module Combination

In Figure 39, note that the LEDs and selection switch are positioned at the top of the board so that the serial and MMJ connector cables do not interfere with access to them. The serial connector is positioned above the MMJ connectors and away from the bottom of the handle because the right-angle serial-connector cable is very rigid and inflexible at its base.

The serial connector would be obstructed by the bottom protrusion of the recessed handle if it were positioned too close to the bottom of the handle.

4.3 FLUSH HANDLE DESIGN EXAMPLE

This example shows how to proceed in the design of a module with I/O and LEDs using a flush handle, allowing use of the module in BA200 and non-BA200 Series enclosures (for example, BA23 or BA123).

4.3.1 Product Description

The product is a communications module with three LEDs and an I/O ribbon cable connector located at the edge of the module. The module is shown in Figure 41. Note that in Figure 40, the module is shown having a 12-13113-01 card ejector handle. This 12-13113-01 handle cannot be in place if a BA200 Series handle is to be installed.

Figure 41: Module With Three LEDs, Fuse and Ribbon Cable

4.3.2 Approach

This design uses a flush handle and routes a round flexible cable from the I/O connector on the board to a connector on the handle. A round flexible cable is used to route the cable to the handle because it covers less surface area of the board and allows better air flow.

Since this approach uses a flush handle, there will be some clearance between the handle and the LEDs located on the board. In this case, pipes should be added to the LEDs so that their light can be seen despite the clearance. The handle is shown in Figure 42.

Figure 42: Module Riveted to Handle

4.4 COVER DESIGN EXAMPLE

This example shows a module without external I/O using a cover.

4.4.1 Product Description

The product is an existing memory board without I/O connectors.

4.4.2 Approach

The best approach is to choose a single cover because there are no I/O connectors. The single cover is shown in Figure 43. Insert the module into the backplane and cover its slot with the single cover.

Figure 43: Single Cover and Module

4.5 DESIGN EXAMPLE USING A DUAL FILLER PANEL

This example shows how to use a dual filler panel in order to support a dual-height module.

4.5.1 Product Description

The product is a dual-height module.

4.5.2 Approach

Because the product is a dual-height module, a dual filler panel must be riveted to a flush or recessed handle. Select the handle that is appropriate for the enclosure. The dual filler panel provides support to the module and allows for proper air flow within the enclosure. A dual-height module and dual filler panel riveted to a flush handle are shown in Figure 44.

Figure 44: Flush Handle and Dual-Height Module

5 NOMENCLATURE AND STRUCTURE OF BA200 SERIES OPTIONS AND MODULES

The following sections describe the nomenclature that has been adopted for BA200 Series Options and include guidelines on how to correctly structure and document a BA200 Series Option at both the option and module levels.

5.1 BA200 SERIES OPTION LEVEL

The BA200 Module Option scheme recognizes the -S* nomenclature at the option level. The -S* variants are intended for BA200 Series options only.

The recommended option variation scheme is to create individual -S* variations for each of the factory-embedded and field-installed variations of an option. For example, factory-embedded variations can be indicated by -SA, -SB, or -SC, and field-installed variations by -SX, -SY, or -SZ. A BA200 Series option can have a number of factory-embedded and/or field-installed variations, as long as each variation is distinguishable from the others by its own -S* part number. For the examples throughout the remainder of this document, -SA was chosen to indicate a factory-embedded option and -SF a field-installed option.

When a customer orders an option for a BA200-type unit, the option must include the necessary hardware to properly install the option and maintain FCC compliance. Therefore, the customer must order the BA200 variation of that option in order to get all the additional hardware.

A customer can order an option to be embedded in a system at time of production or the option can be field installed. Each has its own part number.

When embedded, there is a minimal amount of material required since the system is configured by XCON and the needed material is immediately known during manufacturing.

When the option is to be field installed, the system configuration is not known and therefore additional material and documentation must be included to ensure installability.

The Systems and Options Catalog should clearly explain which part number to order depending on the need for an embedded or field-installed module option.

For non-BA200 options, the customer in many cases has to order two (2) items, the module and the bulkhead kit. Each has a separate part number. For BA200 options, only one (1) part number is necessary. The customer will automatically get the necessary bulkhead.

The embedded option is sourced to the system plant. The system plant orders the option module and other loose piece parts separately. Many of the loose piece parts are already common items used within the system plants for BA200 production. Multiple installations of the same option usually do not require the same multiple of loose piece parts, but some may require less.

The field-installed option kit is preferably sourced to the option plant and POM'd from either the option plant or from a warehouse such as Contoocook, NH. The idea here is to keep inventory on the low side as much as possible.

As for handles that must be attached to modules, again the option plant is the choice site. Only they have the expertise to test the option and ensure that a quality product is delivered to the customer.

With the factory-installed options being sourced to the system plant, manufacturing can include, in the standard cost, value added for installing and system testing the option. This allows manufacturing to easily and accurately cost out any system, regardless of configuration.

The basic -SA variation should consist of only the module and nothing else, unless Stage 2 Manufacturing or Consolidation requires additional pieces to satisfy distribution plans. This variation should be the Factory Installed Line Item Option. It is structured on the concept that all required external cables are also Customer Orderable Items.

If a -SF variant of the option is being offered, it should consist of the following as a minimum: (Please refer to the sample K-PLs and the BA200 Series Option Hierarchy Documentation trees for guidance.)

1. Module (M1234-P or M1234-AA).
2. Installation guide (for example, EK-OPTSA-IN).
3. Exterior double-deep carton p/n 37-00931-04. (An exterior triple-deep carton is also available, see p/n 37-00931-07.)

4. 36-26883 Module Identification Label (for options consisting of modules using detached bulkheads).
5. 36-29163 Module Revision Label (for options consisting of modules using detached bulkheads).
6. Gap Filler Kit. (p/n 70-24505-01 two-packaged gap fillers, 70-24071-01 one-unpackaged gap filler).

Other items which may be required as determined by Product Management and/or CSSE are:

1. User Guide.
2. Special Cable(s).
3. Special Loopback Connector if required for user-run diagnostics.

5.2 BA200 SERIES MODULE LEVEL

The BA200 Series modules with attached BA200 Series bulkheads are distinguished from modules with the 12-13113 card ejector or magenta handles by having a -P suffix (M1234-PA, M1234-PB, and so forth). The 70-class bulkhead assembly appears on the M1234-P parts list. Refer to Appendix A for sample parts lists and BA200 Series Option Hierarchy Documentation trees for guidance.

Modules with detached bulkheads which use the single or double covers employ the traditional suffixes (M1234-AA, M1234-YA, and so forth). These modules use either the 12-13113 card ejector or magenta handles which appear at the M1234-AA parts list. The bulkhead cover assembly appears at the option level parts list if it is unique to that option (if functionality distinguishes that cover assembly from others). An H number (or other legal option number) may be assigned to a unique bulkhead cover assembly (for example, H3600, H3601), allowing customers to order the part separately. Single-width blank covers are called out at the system level parts list as required for modules not requiring external I/O connection (for example, TQK50).

All modules with attached BA200 Series bulkheads (handles) must have the following specific items called out on the M1234-P parts list:

- Handle-less variation of module.

NOTE

It is suggested that a variation of the module be created consisting of just the 50-class bare board and components. This variation can be the basis of all subsequent variations. If this handle-less variation is treated as a sub-assembly (called out as a single line item) within other variations with handles, changes made to this base module will be seen by all variations using this base module.

- The proper variation of the 70-class handle assembly. (The 70-class assembly consists of the cast or sheet metal handle, FCC clips, EOS clips, latches and hardware.)
- 36-26883 Module Identification Label.
- 36-29163 Module Revision Label.
- Appropriate quantity of eyelets, p/n 90-00024-01 for handle attachment.
- External connectors (d-subs, miniature modular jacks, and so forth).

- 54-class distribution board (if used) which mounts in back of the handle (for example, DZQ11-S).
- The module packaging p/n 37-00931-01 (quantity 1), with a NOTE as follows: "37-00931-01 is the required individual package; for inter-plant shipment reference bulk multi-pack variations 37-00931-02/03."

6 BA200 SERIES MODULE RELEASE STEPS

Designers are expected to:

- Use this document for rules, suggestions and general guidance.
- Design handles/bulkheads for their own modules using the BA200 Series Bulkhead type which best suits their needs (for example, single cover, double cover, recessed handle or flush handle). It is preferred that an attached bulkhead design be used when feasible. The attached bulkhead designs prevent chafing of internal cables when adjacent modules are installed or removed.
- Create a silkscreen to be called out on the 74-class parts list. All special handle markings should be in accordance to *DEC STD 178-5 Marking Symbology* and must have graphic artwork created. The silkscreen should be created prior to submitting the ECOs for the new 70- and 74-class bulkhead variations so the silkscreen can be included in the ECO. The silkscreen identifier should follow the basic part number of the 74-class bulkhead (for example, a silkscreen created for a 74-33638 type bulkhead should be identified as B-SS-7433638-X-0 where X corresponds to the next available silkscreen variation).
- Request the Micro Systems Engineering Support Unit (Larry Mazzone, 247-2758, MSESU::) to review both initial design and ECO. This is essential to ensure that design changes to bulkhead tooling remain consistent with enclosure and box hardware changes. ECOs remain the sole responsibility of the designing group. Unless new handle designs and ECOs have been reviewed and accepted, the Micro Systems Engineering Support Unit cannot be responsible for communicating new tooling requirements to bulkhead vendors, or ensuring continuing consistency between enclosure and bulkhead specifications.
- An ECO to the 74- and 70-class documents creating a new variation of the type of bulkhead being used must be submitted only after a level of confidence in the design has been achieved. It is preferred that the design engineer research the use of an existing variation if possible. The ECO adding the variation to the 74- and 70-class base drawings of the type of bulkhead chosen for the design must include the following:

  1. B size sketches/drawings of 74-class variation being added. (These drawings must show silkscreen markings.)
  2. Engineering sign-off information (name, DTN, cost center).
  3. Field service sign-off information (name, DTN, cost center).
  4. Manufacturing sign-off information (name, DTN, cost center).
  5. Where used.

6. Product family.
7. Charge number.
8. Expected volumes.
9. Break-in/effectivity dates.
10. Documents effected.
11. Manufacturing site coordinator.

See sample engineering change orders for guidance.

- Create a variation of the 36-26883 Module Identification Label. The module number label attached to the bulkhead assembly shall reflect both the option and module numbers of the design.
- Create the appropriate BA200 Series Module Level variation and appropriate documentation (for example, K-PL-M1234-0-DBP, D-UA-M1234-0-DBU, K-DD-M1234-0-0). If module documentation already exists, it must be ECO'd to reflect the new -P variation. It is preferred that all variations of a module reside on the same K-PL, K-DD, D-UA, and so forth. See sample K-PLs and BA200 Series Option Hierarchy Documentation trees in Appendix A for guidance.
- Create the appropriate BA200 Series Option Level variation and documentation (for example, K-PL-OPTION-S-DBP, B-DD-OPTION-S-0, B-TC-OPTION-S-0). If option documentation already exists, it must be ECO'd to reflect the new -S variation(s). It is preferred that all variations of an option reside on the same K-PL, K-DD, D-UA, and so forth. See Appendix A and sample K-PLs and BA200 Series Option Hierarchy Documentation trees for guidance.
- Ensure Module and Option level parts lists reflect proper packaging. New packaging has been created for shipping BA200 Series modules having attached handles. Packaging spec C-PA-3700931-0-DBU consists of individual, bulk and customer cartons.
- Ensure that the BA200 Series Option complies to all applicable DEC Standards (for example, *DEC STD 102-0 Environmental Standard for Computers and Peripherals - General Test Requirements*, DEC STD 103-0, *DEC STD 119-0 Digital Product Safety - Introduction and General Requirements*, and so forth).

  Option testing should include:

  Design Verification Testing.
  Reliability/Quality Testing.
  Low End Systems Evaluation Engineering Testing.
  Electrostatic Discharge (ESD) and Electrical Overstress (EOS) Testing .
  Electromagnetic Compatibility (FCC, VDE) Testing.
  Product Assurance Testing.
  System Qualification.
  POM Qualification. Contact the Micro Systems Development System Integration Group to arrange for system qualification of the new BA200 Series Option.

APPENDIX A

BA200 SERIES OPTION HIERARCHY DOCUMENTATION TREES AND SAMPLE PARTS LIST

Figure 45: Example of BA200 Series Option Hierarchy - Option with External I/O that uses an Attached Handle

Figure 46: Example of Parts List - Option with External I/O that uses an Attached Handle

Figure 47: Example of Parts List - Module with Attached Handle

Figure 48: Example of BA200 Series Option Hierarchy - Option with External I/O that uses a Detached Cover

Figure 49: Example of Parts List - Option with External I/O that uses a Detached Cover

Figure 50: Example of Parts List - H36NN Bulkhead

Figure 51: Parts List - H36NN Bulkhead Distribution Board

Figure 52: Example of Parts List - Module

Figure 53: Example of BA200 Series Option Hierarchy - Option with No External I/O that uses a Detached Cover

Figure 54: Example of Parts List - Option with No External I/O that uses a Detached Cover

Figure 55: Example of Parts List - Module

APPENDIX B

SAMPLE ENGINEERING CHANGE ORDERS TO CREATE NEW 70- AND 74-CLASS VARIATIONS OF BA200 SERIES BULKHEADS

Figure 56: Sample ECO to Create New 74-Class Variation

Figure 56 Cont'd on next page

Figure 56 (Cont.): Sample ECO to Create New 74-Class Variation

Figure 56 Cont'd on next page

Figure 56 (Cont.): Sample ECO to Create New 74-Class Variation

Figure 57: Sample ECO to Create New 70-Class Bulkhead Assembly Variation

Figure 57 Cont'd on next page

Figure 57 (Cont.): Sample ECO to Create New 70-Class Bulkhead Assembly Variation

APPENDIX C

REFERENCED DOCUMENTS

C.1 EL-Class Digital Documents

EL-Class Number	Document Title
EL-00030-05	*DEC STD 030-5 Module Manufacturing Standard—Module Assembly and Component Insertion Rules*
EL-00052-04	*DEC STD 052-4 Local Direct Connection (No Modem) for Serial Asynchronous Terminals and System Interfaces*
EL-00102-00	*DEC STD 102-0 Environmental Standard for Computers and Peripherals - General Test Requirements*
EL-00103-00	*DEC STD 103-0 Electromagnetic Compatibility (EMC) Hardware Design Requirements*
EL-00119-00	*DEC STD 119-0 Digital Product Safety - Introduction and General Requirements*
EL-00176-00	*DEC STD 176-0 Printed-Wiring Board Acceptance Criteria*
EL-00178-02	*DEC STD 178-2 Digital Marking Requirements for Subassemblies: Field Replaceable Units (FRU) and Non-Field Replaceable Units*
EL-00178-05	*DEC STD 178-5 Marking Symbology*
EL-ENPCB-00	*PC Board Engineering Handbook*
EL-SM030-00	*DEC STD 030 Module Manufacturing Standard*

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C.2 Related Documents

Order Number	Document Title
A-PS-3626883-0-0	*Label, BA2XX Module Number*
A-PS-3629163-0-0	*Label, BA2XX Rev Rolled*
C-PA-3700931-0-DBU	*Packaging Specification for Sbox Handles*

Purchase Specifications are available from any Microfilm Reference File (35mm aperture card "tub") or the SPOC system.

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